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Image Registration Method for Satellite Image Sensing using Feature based Techniques

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ABSTRACT

Identifying targets (sensed image) on large satellite images (reference image) is a difficult task and consumes time. In this paper an image registration method for satellite image sensing using feature based techniques is proposed for detecting the targets. Image registration is the process of sheathing images of the same scene with respect to a particular reference image. Classical registration methods are used for registering the images but they have certain limitations in their accuracy. Method proposed and implemented here has good response target matches and depicts 76 percent accuracy with the best combination of feature extractor and detector.

Key words: Classical registration, Image Registration, Satellite image, Remote sensing, Image Features, sheathing.

1. INTRODUCTION

Image registration involves assigning of one image as reference image and applying geometric transformations to another image so that they align with each other. Here misalignment of images can happen for different reasons. Images are captured under uncertain conditions leads to change in the content of the scene. Lens and sensor distortions or differences between capturing devices can also result in misalignments[1]. Registering of images is performed by various feature based methods and area based methods. The area-based method involves matching of original image data with negligible pre-processing. Area based methods are frequently labelled as correspondence less matching with an intact area matched without constructing a correspondence between reference and sensed image points. On the other hand, in feature-based methods, highly elucidative features are extracted from the original images for matching. This method can extract typical control points and detect thick edges or contour maps[2-4].
Reference images cover most of the area in a single picture; these images are mostly satellite images (Google Earth images) altitudes according to the requirement. Sensed images are camera ready images captured with the help of drones and other equipment. The sensed images are the targets to be detected in the reference image. Finding a target in these Images can be done using many feature based methods and area based methods. Here the objective is to draw a bounding box around the target in the reference image and find the number of good matches for the detected output. The features are extracted and detected by the registration methods with a ratio that is best fit for matching the images.
The sections are arranged as follows Section 2 explains about the literature review on image registration methods with their pros and cons. Section 3 proposes an algorithm and the data used. Section 4 discusses the results obtained and section 5 gives conclusions with future research directions.

2. LITERATURE SURVEY ON IMAGE REGISTRATION METHODS

Feature Based Image Registration

The major part in image registration method is feature extraction from the images. The features are extracted as key points and descriptors so as to map with other features. There are different methods existing for extracting features as key points leading to descriptors. All these methods with their advantages and limitations are discussed below.

2.1 Oriented FAST and Robust BRIEF:

ORB(Oriented Robust Brief) is a fusion method of registering image based on features of segmented test called as Features from Accelerated Segment Test (FAST)[5].It uses a key point detector and descriptor called as BRIEF(Binary Robust and Independent Elementary Features) its performance improves when used with top N points among them. It applies Harris corner measure to find descriptor on BRIEF. In this method each bit feature has more variance and a mean approximately nearing to a 0.5 value. Large variance has more criticality when responding to different inputs. Once the data gets trained with the key points variance gets more distributed.
ORB works on greedy search technique with binary tests having good variance and uncorrelated mean value nearing to 0.5.This varied method is called as rBRIEF[6-8] .

2.2 Speeded Up Robust Features:

Speeded Up Robust Feature (SURF) image registration method works on approximating Laplacian of Gaussian (LoG) coefficient with a box filter. SURF approximation has the advantage of convolving box filters using integral image. It is paralleled for varying scales based on Hessian matrix determinants. Basically SURF works on wavelet responses relying on location and scale of determinant .A neighbourhood size of 6 are used for assigning vertical and horizontal directions. Gaussian Weight is applied for ease of integral images. A 20sX20s neighbour size is considered for the key point and divided into 4 sub regions. Each sub region has a horizontal and vertical vector formed through its wavelets. This method provides better distinct feature selection on variety of features. The speed of SURF inversely depends on image dimensions. Smaller the image better is the computation and matching speed. Performance of this method is increased by 3 folds as compared to Scale Invariant Feature Transform (SFIT).The advantage of this method is blurring and rotation of images is well handled. The limitation of this method is it deteriorates in its performance when image view point or image illumination change occurs[9].

2.3 Scale Invariant Feature Transform:

SIFT is a point matching descriptor used for recognizing satellite images projected between diverse views. This descriptor method works irrespective of transformations on rotation, translation and scaling variations. This algorithm works on five basic points as stated below.

1) **Scale-space extrema detection:**

Larger window size is required to detect larger corners. For this, scale-space filtering is used. Laplacian of Gaussian (LoG) is found for the image with various alpha values. LoG acts as a blob detector which detects blobs in various sizes due to change in alpha as shown in Fig. 1

2) **Key point Localization :** To get more accurate results the key points have to be refined after the possible key point locations are found. Taylor series expansion is used to get more accurate location of extrema .The extrema is rejected if the intensity is less than a threshold value called contrast threshold.

3) **Orientation Assignment:** To achieve invariance to image rotation an orientation is assigned to each key point. A neighborhood is taken around the key point location depending on the scale, and the gradient magnitude and direction is calculated in that region.

4) **Key point Descriptor:** Now key point Descriptor is created with a 16x16 neighborhood around the key point taken. It is divided into 16 sub-blocks of 4x4 sizes. For each sub- block 8 bin orientation histogram is created. So a total of 128 bin values are available. It is represented as a vector to form keypoint descriptor. Several measures are taken to achieve robustness against rotation and illumination changes.

5) Keypoint Matching: Keypoints between two images are matched by identifying their nearest neighbors. But in some cases, the second closest-match may be very near to the first[10-11]. It may happen due to noise. In that case, ratio of closest-distance to second-closest distance is taken If it is greater than 0.8, they are rejected. It eliminates around 90% of false matches while discards only 5% correct matches.

Advantage of SIFT is robust in nature and invariant on illumination and transformation. Limitation is dependent features having more impact on image registrations.

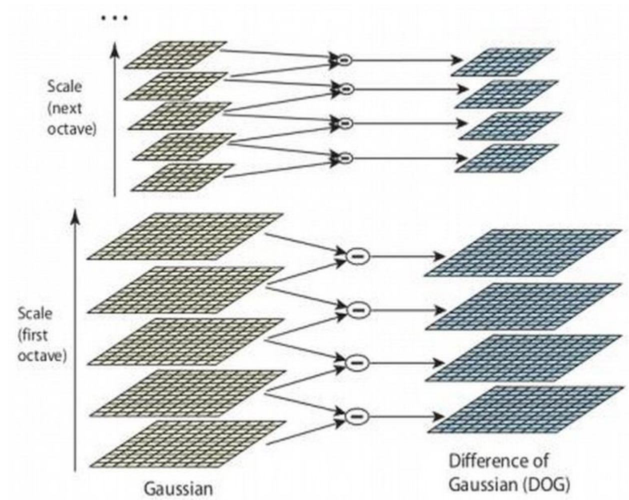

Figure 1: Scale-space Extrema

2.4 ***Binary Robust and Independent Elementary Features BRIEF*** **:**

Binary Robust and Independent Elementary Features (BRIEF) provides a route to find the binary strings directly without finding descriptors. A set of location pair is selected with the help of image patch to find suitable descriptor. The limitation here is it can find only a feature descriptor but doesn't help in finding the features[12]. Hence requires other feature detecting methods it cannot operate independently.

3. PROPOSED METHOD

3.1 Algorithm

Following are the steps involved in the proposed algorithm.

i. Read reference and sensed images using openCV.
ii. Extract features from both the images using extractor and detector functions.
iii. Generate and identify key points and descriptors
iv. Store all the key points and descriptors extracted from the images.
v. Apply Brute-force matcher to match all the key points and descriptors.
vi. Locate better matches using Lowe's ratio test from the keypoints and descriptors generated.
vii. Find homograph for the keypoints using Random sample consensus (RANSAC) function for mapping matcher points.
viii. Estimate and perform mapping of sensed image with reference image using perspective transform.
ix. Detect target with a bounding box in the reference image for the mapped features.

Proposed Algorithm method process shown in fig 2 is implemented using OpenCV tool to extract keypoints and descriptors from the images and find the good matches useful for identifying the target. The registration process is involved with geometric transformations which help to get increased number of accurate matches compared to existing methods.

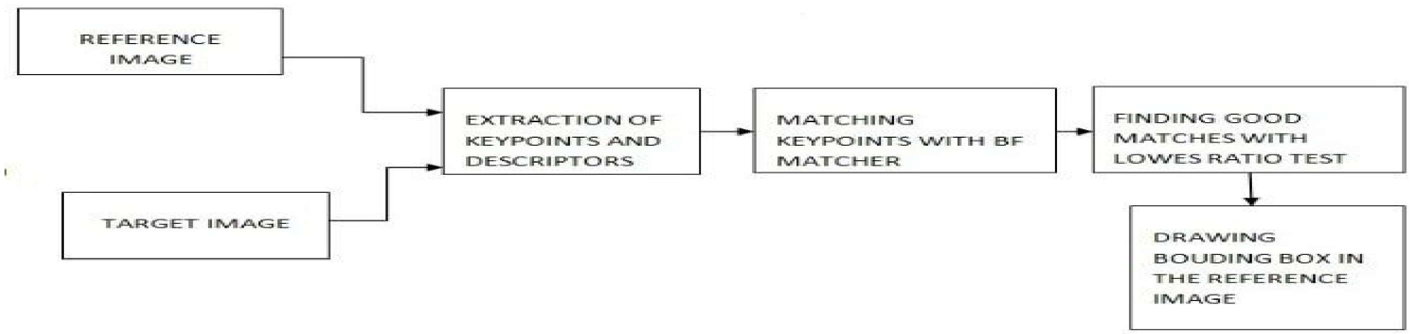

Figure 2: The process of proposed registration method

3.2 Dataset

Proposed Algorithm is implemented on high resolution images taken from Google earth [13]. It is considered a as reference images for extraction of features. Images collected from drone are used as sensed images. The reference images collected are resized to 1920 x 1080 pixels and the sensed images are resized to 640 x 480 pixels. The openCV tool is used for implementation on Intel core i7 processor with 16 GB RAM.

4. DISCUSSION ON RESULTS

Implementation results from table 1 show the combination of extractor and detector used in the proposed method. It shows the ratio and good matches obtained from the data set used for satellite image registration to accurately identify targets.

Table 1: Matches Obtained by Registration Methods

Extractor	Detector	Ratio/Good Matches
SIFT	SIFT	0.75/140
SURF	SIFT	0.86/254
ORB	SIFT	Invalid Combination
ORB	ORB	0.75/382

From the obtained results it is inferred that mapping good matches vary based on image data and combination of extractor detector registration method used. The proposed method is tested for the images with different combination of feature extractor and detector

The implemented results show best combination of extractor and detector with maximum good matches of 382 between reference and sensed satellite image.

The SIFT based image registration although gives results with 0.75 ratio has less number of matches. Our proposed method prefers combination of SURF as feature extractor and SIFT as feature detector gives better good matches with same ratio as of SIFT.

5. CONCLUSIONS AND FUTURE SCOPE

In this paper we have successfully implemented an image registration method for satellite image sensing using feature based extractor and detector.

Proposed method is tested on 25 different images out of which 19 images were exactly mapped as that of target in the reference image, giving the accuracy of proposed method to 76%. Our method has also responded well with good matches for the targets which are far away in the reference image. Results also depict the best combination of feature extractor and detector method for satellite image registration.

Our results as shown in fig 3 successfully detects target with bounding box from the reference image with a match ratio of 0.75.The obtained match ratio is comparatively better than the existing image registration methods.

The same technique can further be implemented for RGB and thermal images which have lot more medical and commercial applications. This algorithm can also be further modified for video frame extractions leading to better research directions on object detections in streaming and live videos.

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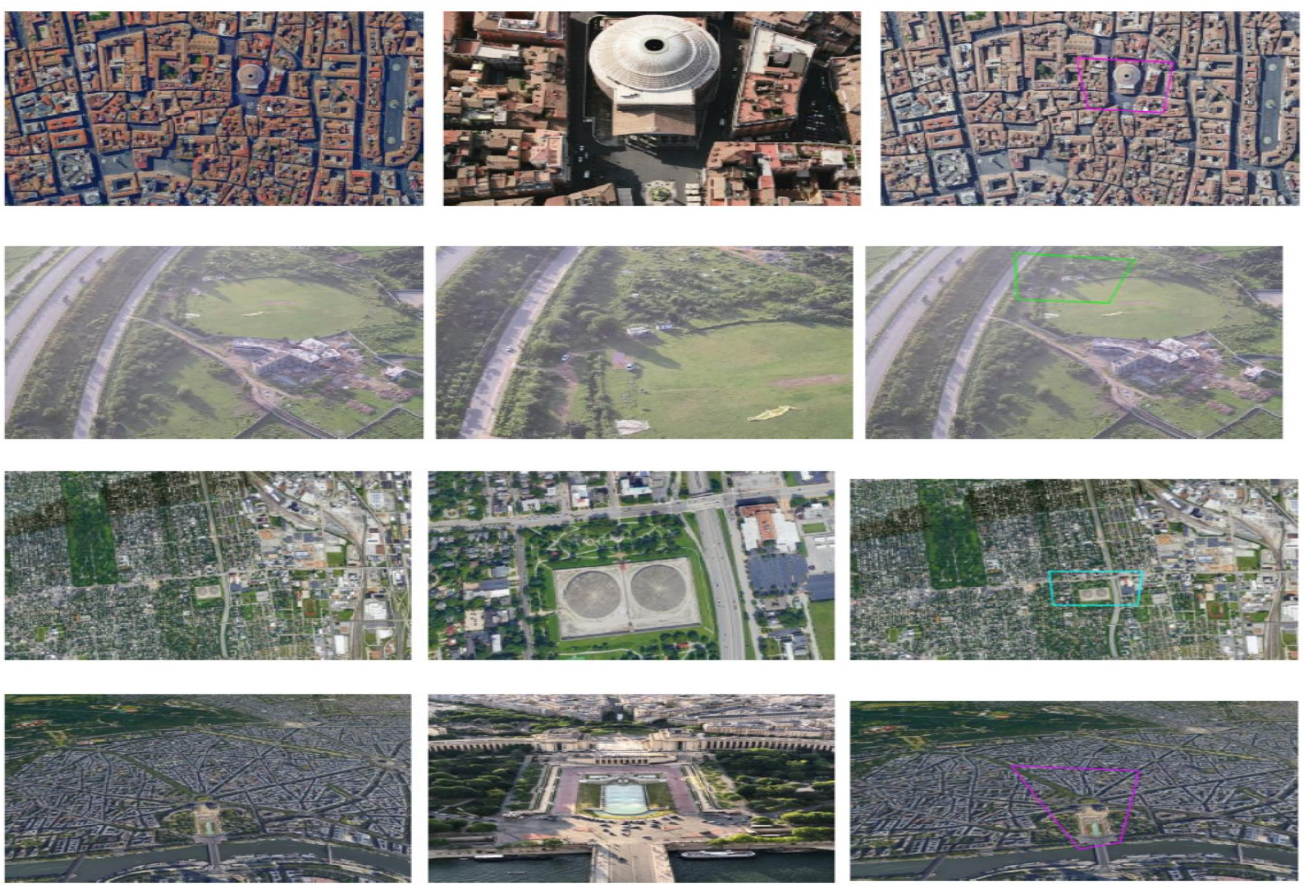

Figure 3: The first column shows reference images, second column shows sensed images and the third column shows the result with bounded box detecting target